PRODUCTION AND PRESERVATION OF CARROT JUICE

By

ALIA MOHAMED ALI EL GHARABLY

A thesis submitted in partial fulfillment

of

the requirements for the degree of

MASTER OF SCIENCE

in

Agriculture

(Food Science & Technology)

Department of Food Science

Faculty of Agriculture

Ain Shams University

1993

APPROVAL SHEET

PRODUCTION AND PRESERVATION OF CARROT JUICE

By

ALIA MOHAMED ALI EL GHARABLY

B.Sc. (Food Technology), Ain Shams University (1987)

Fac. Agric., Ain Shams University

This thesis for M.Sc. Degree has been approved by :

Prof. Dr. S. A. SOLIMAN ..... S. A. Soliman .....

Prof. of Food Science,and Technology
ılty of Agriculture,
ıtohor,Zagazig University.

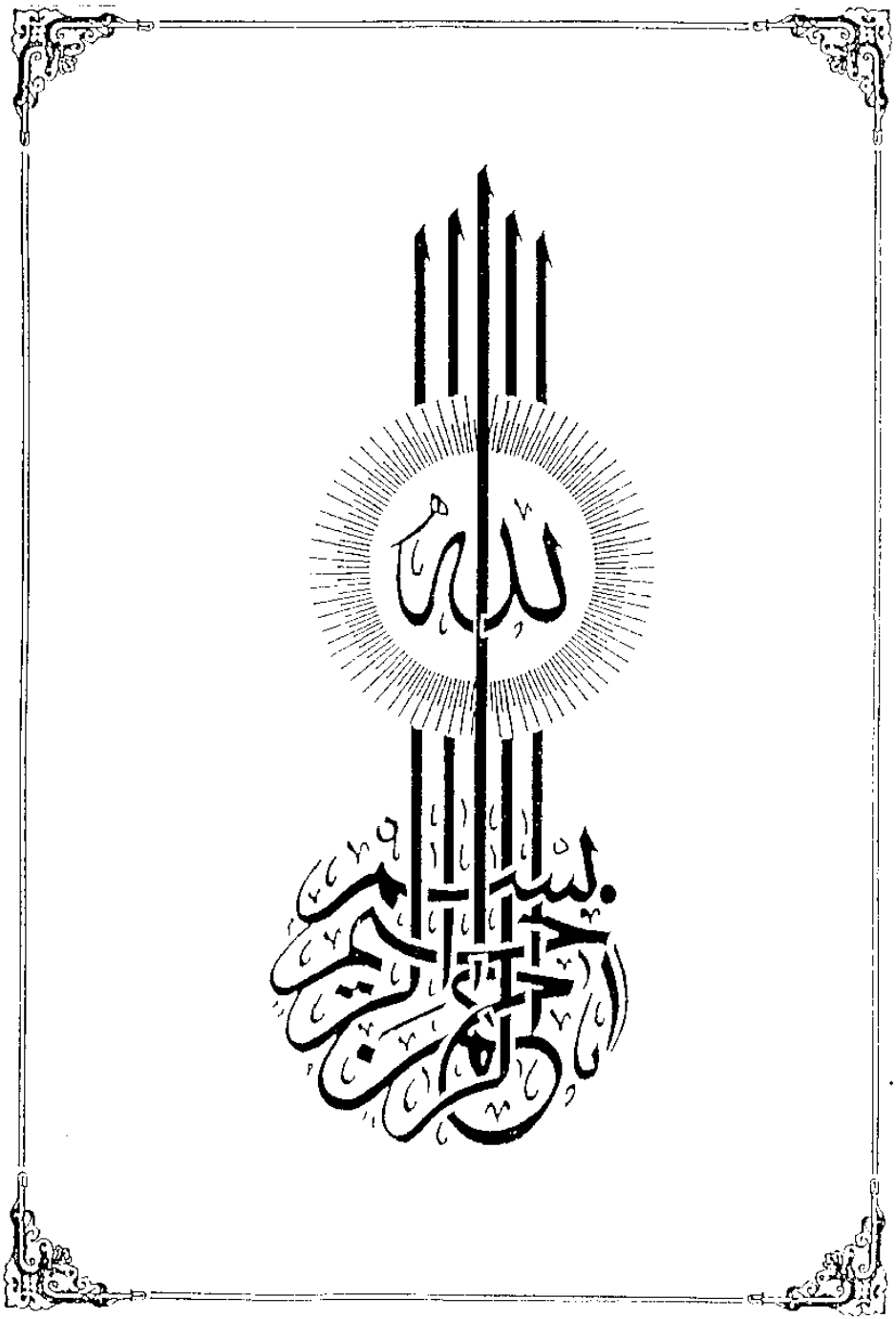
.f. Dr. MAGDA H. ALLAM ..... Magda H. Allam ..

of. of Food Science and Technology
ıculty of Agriculture,
n Shams University.

of. Dr. A. S. DABASH ..... A. S. Dabash .....

of. of Food Science and Technology
:ulty of Agriculture,
ı Shams University.

e of examination 24 / 11 /1993.



PRODUCTION AND PRESERVATION OF CARROT JUICE

By
ALIA MOHAMED ALI EL GHARABLY
B.Sc. (Food Technology)
Faculty of Agriculture, Ain Shams University (1987)

Under the supervision of :

Prof. Dr. A.S., Dabash
Prof. of Food Science and Technology
Fac.of Agric., Ain Shams University.

Dr. Y. A. Heikal
Assoc. Prof. of Food Science and Technology
Fac.of Agric., Ain Shams University.

Dr. Magdy Gomaha El Shemy
Assoc. Prof. of Food Science and Technology
Fac. of Agric. Ain Shams University.

ABSTRACT

Results showed that some pretreatments and commercial macerating enzymes increased the yield of carrot juice. The macerated carrot juices were concentrated and dehydrated by foam-mat and spray drying methods. Tabulated data elucidated chemical, physical and rheological properties of different investigated carrot juices.

KEY WORDS :

Carrot juice - macerating enzyme - cellulase - pectin methyl esterase - blanching - Ascorbic acid - microwave - - concentrated - Foam-mat - spray drying - Carotenoids - Solubility - dispersability - viscosity - Hygroscopicity - Moisture sorption - Moisture sorption isotherm - water activity.

ACKNOWLEDGMENT

The author wishes to express her sincere thanks and deep gratitudes to Prof. Dr. A. S. Dabash, Professor of Food Science and Technology, Food Sci. Dep. Fac. of Agric., Ain Shams University for his continuous supervision, guidance, reviewing the thesis, and for his valuable critism during the course of this study.

My special thanks is extended to Dr. Y.A. Heikal, Assoc. Prof. of Food Technology and Engineering, Food Sci. Dep., Fac. of Agric., Ain Shams University for supervision as well as for all the effective advices he offered and for his continuous valuable helpfulness throughout the investigation.

My deepest gratitude is extended to Dr. M. G. El Shemy, Assoc. Prof. of Food Science and Technology, Food Sci., Dept., Fac. of Agric., Ain Shams University, for his helpful suggestions, supervision and every possible guidance he kindly offered through the whole work.

CONTENTS

	Page
APPROVAL SHEET	i
ABSTRACT	ii
ACKNOWLEDGMENT	iii
LIST OF TABLES	ix
LIST OF FIGURES	xv
LIST OF ABBREVIATIONS	xxi
1. INTRODUCTION	1
2. REVIEW OF LITERATURE	5
2.1. Production of carrot , other vegetable and fruit juices by using macerating enzymes	5
2.1.1. Pretreatment by blanching	5
2.1.1.1. Blanching by microwave.....	5
2.1.1.2. Blanching in boiling water	6
2.1.2. Properties of selected enzymes used in maceration	7
2.2. Preservation of carrot juices	17
2.2.1. Concentration by evaporation	17
2.2.2. Dehydration of carrot , other vegetable and fruit juices	18
2.3. Some physical, chemical and rheological properties of carrot and some fruit juices..	22
2.4. Equilibrium relationships of dried foods with water vapour.....	25
3. MATERIALS AND METHODS	31
3.1. Materials	31
3.1.1. Carrots and tomatoes	31
3.1.2. Enzymes	31
3.1.2.1. Commercial enzyme preparates	31
3.1.3. Citrus pectin	31
3.1.4. Carboxy methyl cellulose	31
3.2. Methods	31

Page

3.2.1. Technological methods 31
3.2.1.1. Production of carrot juices 31
3.2.1.1.1. Pretreatment methods for producing carrot juice 32
1. Addition of ascorbic acid without blanching 32
2. Blanching in boiling water and ascorbic acid addition 32
3. Microwave blanching 32

3.2.1.1.2. Enzymatic maceration and extraction of carrot juices..... 32
1. Sigma cellulase enzymes..... 33
2. Pectinol enzymes..... 33
3. Pectinex ultra SP-L enzyme preparates 33
4. Pectinex 3x-L enzyme preparates 34

3.2.1.1.3. Mixing tomatoes juice with carrots mash 34

3.2.1.2. Preservation of produced carrot juice.. 35

1. Concentration of carrot juice by evaporation 35

2. Dehydration methods 35
a) Spray-drying 35
b) Foam-mat drying 35

3.2.2. Analytical methods 36
3.2.2.1. Enzyme preparations 36

1. Cellulase activity..... 36
- Enzyme extraction 36
- Reagents 37
- Enzyme assay 37
- Calculations 37
- Unit activity 38

3.2.2.2. Properties of (Novo- and Sigma cellulase) and cellulase extracted from carrots and tomatoes..... 38

1. Effect of pH 38
2. Effect of temperature 38
3. Enzyme concentration 38
4. Substrate concentration 38

2. Pectin methyl esterase activity 39
- Enzyme extraction 39

Page

- Reagents 39
- Indicator dye 39
- Enzyme assay 40

3.2.2.3. Properties of pectinol and pectin methyl esterase extracted from carrots and tomatoes 40

1. Effect of pH 40
2. Effect of temperature 41
3. Effect of enzyme concentration 41
4. Effect of substrate concentration 41

3.2.2.2. Chemical, physical and rheological analysis 42

1. Moisture content..... 42
2. Total solids 42
3. Total soluble solids 42
4. Titratable acidity 42
5. Total and reducing sugars 42
6. Ascorbic acid 42
7. Total carotenoids 42
8. The pH 43
9. Refractive Index (RI) 43
10. Measurement of browning 43
11. Solubility 44
12. Dispersibility 44
13. Viscosity 44
14. Hygroscopicity 46
15. Moisture sorption 46
16. Moisture sorption isotherm 47

4. RESULTS AND DISCUSSION 49

4.1. Properties of enzymes used for producing carrot juices 49

4.1.1. Cellulase 49
4.1.1.1. Effect of enzyme concentration 49
4.1.1.2. Effect of substrate concentration 52
4.1.1.3. Effect of pH 55
4.1.1.4. Effect of temperature 59
4.1.1.5. Activation energy 62

4.1.2. Pectin methyl esterase (PME) 64
4.1.2.1. Effect of enzyme concentration 64
4.1.2.2. Effect of substrate concentration 68
4.1.2.3. Effect of pH 72
4.1.2.4. Effect of temperature 75
4.1.2.5. Activation energy 79

Page

4.2. Production of carrot juices 82
4.2.1. Activity of selected enzymes used in maceration 82

4.2.2. Carrot juices yield as a function of used selected enzymes 84

4.2.3. Production of mixing tomato juice with carrot mash 91

4.2.4. Some properties of mixing tomato juice with carrot mash 96
4.2.4.1. Moisture content 96
4.2.4.2. Total solids (T.S) 99
4.2.4.3. Total soluble solids (TSS %) 99
4.2.4.4. Titratable acidity and pH 102

4.3. Chemical and physical properties of carrot juices produced by different treatments 105

4.3.1. Moisture content 105
4.3.2. Total solids (T.S) 107
4.3.3. Total soluble solids (TSS) 109
4.3.4. Titratable acidity 110
4.3.5. T.S.S/acid ratio 113
4.3.6. pH 114
4.3.7. Sugar contents 115
4.3.8. Ascorbic acid content 120
4.3.9. Total carotenoids content 125
4.3.10.Solubility 130
4.3.11.Dispersibility..... 133
4.3.12.Browning 135

4.4. Rheological properties of macerated and concentrated carrot juices..... 139

4.5. Equilibrium relationships of carrot juice powder with water vapour 156

4.5.1. Hygroscopicity 157

4.5.2. Moisture sorption 166
4.5.2.1. Modeling of the moisture vapor sorption curves 178

4.5.3. Moisture sorption isotherm 188
4.5.3.1. Fitting of sorption data to various isotherm equations 195

1. Henderson equation 196
2. Halsey equation 198

Page

3. Iglesias and Chirife equation 200
4. Smith equation 202
5. Chung Pfost equation 202
6. The BET equation 204

SUMMARY AND CONCLUSIONS 210

REFERENCES 215

ARABIC SUMMARY ..... -

LIST OF TABLES

Table No.	Title	Page
1	Relation Between Activity and Concentration of Sigma, Novo Cellulase and Cellulase Cxtracted from Carrots and Tomatoes	50
2	Relation Between Substrate Concentration and Activity of Sigma, Novo Cellulase and Cellulase extracted from Carrot and Tomatoes.....	53
3	Effect of pH on Activity of Sigma, Novo Cellulase amd Cellulase Extracted from Carrots and Tomatoes	57
4	Effect of Temperature on Activity of Sihgma,Novo Cellulase and Cellulase Extracted from Carrots and Tomatoes.....	60
5	Relation Between Activity and Concentration of Pectinol and Pectin Methyl Esterase Extracted from Carrots and Tomatoes.....	66
6	Relation Between Substrate Concentration and Activity of Pectinol and Pectin Methyl Esterase Extracted from Carrots and Tomatoes.....	69
7	Effect of pH on Activity of Pectinol and Pectin Methyl Esterase Extracted from Carrots and Tomatoes.....	73
8	Effect of Temperature on Activity of Pectinol and Pectin Methyl Esterase Extracted from Carrots and Tomatos.....	76

		Page
9	Activity of Selected Enzymes Used for Producing Carrot Juices.....	83
10	Effect of Selected Enzyme Preparates on the Yield % of Carrot Juices.....	86
11	Relation Between % Yield and Mixing Ratio of tomato Juice with Carrot Mash at Different Tempeeratures at Various Times of Incubation...	93
12	Moisture Content of Different Mixing Carrot Mash with Tomato Juice.....	97
13	Total Solids (T.S) % of Different Mixing Carrot Mash with Tomato Juice.....	100
14	Total Soluble Solids (TSS) % of Different Mixing Carrot Mash with Tomato Juices.....	101
15	Acidity and pH of Different Mixing Carrot Mash with Tomato Juice on	103
16	Some Physical and Chemical Properties of Untreated Carrot Juice(Calculated on Dry Weight Basis)	106
17	Moisture, Total Solids (T.S), Total Soluble Solids (T.S.S), Titratable Acidity (T.A), TSS/Acid Ratio and pH Values of Macerated and Concentrated Carrot Juices Produced by Different Treatments.....	108
18	Moisture Content, Titratable Acidity (TA) and pH Values of Foam-mat and Spray Dried Carrot Juices Produced by Different Treatments.....	111

Page

19 Sugar Content of Macerated Concentrated Foam-mat Dried and Spray Dried Carrot Juices Produced by Different Treatments (Calculated on Dry Weight Basis)..... 116

20 Ascorbic Acid Contents (mg/100 g) of Macerated, Concentrated Foam-mat Dried and Spray Dried Carrot Juices Produced by Different Treatments (Calculated on Dry Weight Basis)..... 122

21 Total Carotenoids Content of Macerated Concentrated, Foam-mat Dried and Spray Dried Carrot Juices Produced by Different Treatments..... 126

22 Some Physical Properties of Foam-mat and Spray Dried Carrot Juices Produced by Different Treatments..... 131

23 Rheological Data of Macerated Carrot Juices Treated with Cellulase at 30°C..... 140

24 Rheological Data of Macerated Carrot Juices Treated with Pctinol at 30°C..... 141

25 Rheological Data of Macerated Carrot Juices Treated with Pectinex SP-L at 30°C..... 142

26 Rheological Data of Macerated Carrot Juices Treated with Pectinex 3x-L at 30°C..... 143

27 Rheological Data of Concentrated Carrot Juices Treated with Cellulase at 30°C..... 144

28 Rheological Data of Concentrated Carrot Juices

		Page
	Treated with Pectinol at 30°C.....	145
29	Rheological Data of Concentrated Carrot Juices Treated with Pectinex Ultra SP-L at 30°C.....	146
30	Rheological Data of Concentrated Carrot Juices Treated with Pectinex 3x-L at 30°C.....	147
31	Flow Paramter Constants of Macerated, Concentrated Carrot Juics at 30°C.....	154
32	Moisture Content as Function of Time for Spray Dried Carrot Juice Samples Left at Room Temperature (24°C) and 67% Relative Humidity of Surrounding Atmosphere.....	158
33	Moisture Content as Function of Time for Foam-mat Dried Carrot Juice Samples Left at Room Temperature (24°C) and 67% Relative Humidity of Surrounding Atmosphere.....	159
34	Simple Regression Model for Moisture Absorption (Hygroscopicity) for Spray Dried Carrot Juice Powders Expressed as % Moisture Content (M.C) as a Function of (t) [RH=67%.T 24°C].....	164
35	Simple Regression Model for Moisture Absorption (Hygroscopicity) for Foam-mat Dried Carrot Juice Powders Expressed as % Moisture Content (M.C) as Function of Time. [RH = 67% . T 24°C].....	165
36	Moisture Sorption Data of Spray Dried Carrot Juice Powders as Function of Time on Dry Weight Basis.[^{a}w = 0.754. T = 23°C].....	168

		Page
37	Moisture Sorption Data of Foam-mat Dried Carrot Juice Powders as Function of Time on Dry Weight Basis. [^{a}w = 0.754 , T = 23 $^{\circ}$C].....	171
38	Water Sorption Parameters of Spray Dried Carrot Juice Powders Calculated from Equation(5 and 6).	186
39	Water Sorption Parameters of Foam-mat Dried Carrot Juice Powders Calculated from Equation (5 and 6)	187
40	Moisture Sorption Isotherms of Spray Dried Carrot Juices Powders Pretreated by Ascorbic Acid and Different Macerating Enzymes	190
41	Analysis of Isotherms Data According to Henderson Equation for Spray Dried Carrot Juice Powders Pretreated by Ascorbic Acid and Different Enzymes	197
42	Analysis of Isotherm Data According to Halsey Equation at 25 $^{\circ}$C for Spray Dried Carrot Juice Powders Pretreated by Ascorbic Acid and Different Macerating Enzymes	199
43	Analysis of Isotherm Data According to Iglesias and Chirife Equation at 25 $^{\circ}$C for Spray Dried Carrot Juice Powders Pretreated by Ascorbic Acid and Different Macerating Enzymes	201
44	Analysis of Isotherm Data According to Smith Equation of Spray Dried Carrot Juice Powders Pretreated by Ascorbic Acid and Different Macerating Enzymes	203